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An experimental approach for fly as a part of substitution of cement in characteristics strength studies

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Abstract

Now a days high percentage of motive of research is to use Waste generated in nature by human being is to be utilized and solve the problem of nature contamination due that waste generated. In this process our research concentrated on waste generated in thermal power plants i.e., output fly ash. This fly ash disposal is happening in current scenario is to dump in to sea or river near by that thermal power station. So that there will be contamination of natural resource water. To make this fly ash ecofriendly by utilizing it for the replacement of cement in concrete preparation. So that the amount of cement which is going to be manufactured will be reduced so that the amount of Carbon di oxide emissions will be reduced so as to avoid Global Warming. This fly ash is having physical and chemical properties which are pro to replace cement by little percentage in preparation of concrete. This research work carried to find out at what part of fly ash can be substituted for cement in concrete so that the different strengths of concrete like compressive strength, flexural and tensile strengths can have improved values rather than that of structural elements prepared by conventional concrete. And the research done in laboratory by preparing structural elements with different proportions of parts of fly ash in substituting of cement in concrete and tested. These test results were analysed and found the apt percentage of where the different strengths were found to be more when compared with that of the conventional or fundamental concrete structural elements.

Keywords: Compressive Strength, Flexural Strength and Tensile Strength

1. General Introduction

Concrete is one of the vital materials used in the world for construction works. The demand for it goes up tremendously day by day. To meets such demands, it requires lots of natural resources to be exploited which on the other hand it is dangerous to the environment. So this work concentrates on introducing the use of fly ash in construction as an addressing solution to the nature problems i.e. reduction in the disposal of these by products to the landfills which pose a great threat to the environment and reduction in the emission of carbon dioxide to atmosphere which cause one of the leading problems of the world today, Global warming. Fly-ash is obtained from combustion of coal and consist of silicon dioxide, aluminum oxide and calcium oxide. Fly-ash presents good Pozzolonic properties and react easily with water, so therefore it can be used to partially substituted for cement in the concrete.

The use of waste and by-product provides lot of Advantages. They are (1) Reduce the emission of CO_2 which the cement is always account for it (2) reduces the amount of waste and by-product to entered the landfill sites without proper disposal (3) reduces the exploitation of natural resources, which in the other hand provides a positive impacts to the environment, serves as a renewable source of construction material. For economic and environmental reasons and due to the increase amount of recycled aggregates, there has been a growing interest in global as a whole to maximizing the use of waste and by-materials in the construction. Since it proved successful, hence we can say that waste and by-product can be substituted for natural in many concrete application.

1.2. Fly-ash

They are the by-product from combustion of coal. It is of two types: Class-C and Class-F. The difference is based upon the chemical content present in them. Class-C fly-ash have more lime content as compared to Class-F. The two most properties check upon fly ash are fineness and lime content because these two have a great effect upon the demand of air content and water absorption by the concrete which greatly affect the strength and durability of concrete. The properties of Fly- ash as per IS1727-1967, Specification IS 3812(Part1)- 2013 is shown in table below:

Sl.no	Property	Test Result
1	Lime reactivity	8Mpa
2	Fineness(Blaine)	316m^2/Kg
3	Compressive Strength as percentage strength of corresponding plain mortar cubes	92.33%
4	Soundness by autoclaves expansion	0.0233%
5	Particle shape	Spherical

2. Objectives

The main objectives of this work is to find the optimum parts of fly ash that can be used as a substitute for cement which shows good strength as compared to those of normal concrete.

To meets and reach my objectives, following steps have to be taken into account:

- To find out the slump values of normal concrete and concrete containing fly ash and compare them.
- To find out the hardened behavior of concrete such as Compression, Split- tension and bending.
- To make the concrete economical
- To make concrete light-weight

3. Materials And Research Methodology

3.1General

Before the work is being carried out, the properties of materials is first examined. These materials are Cement of Ordinary Portland cement (OPC) of grade 43, Natural Fine Aggregates, Natural Coarse Aggregate, Fly-Ash of class-C, Sawdust and Coconut Fibre (Coir).

1. Materials
1. Ordinary Portland cement

Following are the properties of cement have been examined:

Type of cement used =Ordinary Portland cement (OPC) of Grade 43

Initial setting time=39minutes

Final setting time=3hours and 10 minutes=190 minutes Fineness Modulus =1%

Specific gravity=3.18 Normal consistency=27%.

1. Natural Fine aggregate

Sieve analysis of fine aggregate:

1Kg of the weight of fine aggregates is taken and the procedures is followed as per IS383.

Sieve seize	Weight of fine aggregate retained(gm.)	Percentage retained	Cumulative percentage retained	Percentage Passing	Permissible percentage as per Is 383
10mm	0	0	0	100	100
4.75mm	0	0	0	100	90-100
2.36mm	0	0	0	100	75-100
1.18mm	760	76.0	76.0	24	55-90
600Mm	164	16.4	92.4	7.6	35-59
300Mm	30	3.0	95.4	4.6	8-30
150Mm	44	4.4	99.8	0.2	0-10
Pan	2	0.2	100	0	

Hence natural fine aggregates is of zone 2 as per IS 383(1970)

A) Water absorption and specific gravity of fine aggregate

Weight of fine aggregate used = 500 grams (w_3) Flask +Water +Fine aggregate = 1830 grams(w_1) Flask+ Water = 1510 grams (w_2)

Weight of fine aggregate after oven dry = 494grams(w_4)

Water absorption = $(w_3-w_4)/w_4$ = (500-494)/494 = 1.2%

Specific gravity = w_4 /[w_3-(w_1-w_2)]=494/[500-(1830-1510)] = 2.74

3.2.3Natural Coarse aggregate

A) Sieve analysis of coarse aggregate

The weight of sample of coarse aggregate tested was=3.480Kg and the procedure was followed as per IS 383 as shown in table below:

IS sieve size in(mm)	Weight of aggregate retained in(gm.)	Percentage of weight retained	Cumulative percentage of total weight retained	Percentage Passing	Permissible value as per Is 383
20	60	1.73	1.73	98.27	85-100
16	1438	41.63	43.36	56.64	
12.5	1404	40.64	84	16	
10	468	13.54	97.54	2.46	0-20
4.75	84	2.46	100	0	0-5
Pan	0	0			

Aggregate is single sized of 20mm size

B) Water absorption of coarse aggregate

Weight of coarse aggregate after surface dry (w_1) = 2.998 Kg Weight of coarse aggregate after oven dry (w_2) = 2.984Kg

Water absorption formula= $(w_1-w_2)/w_1$ = [(2.998-2.984)/2.998]x100 = 0.47% The water absorption of coarse aggregate used is 0.47%

C) Specific gravity of coarse aggregate

Specific gravity is defined as the ratio of the mass of a substance to the mass of a reference substance for the same given volume.

In my project the reference substance used was water. Weight of aggregate used = 3.60Kg

Basket +coarse aggregate) in air = 4.8 Kg

Basket only suspended in air = 0.9Kg Aggregate only in air = 4.8kg-0.9kg = 3.9kg

Aggregate with basket fully submerged in water = 2.9 Kg (w_3) Empty basket fully submerged in water=0.8 Kg (w_2)

Weight of coarse aggregate after oven dry = 3.454kg

Specific gravity=w_4/ [w_4-(w_3-w_2)] =3.454kg /[3.454kg-(2.9kg-0.8kg)]=2.55

The specific gravity of coarse aggregate used is 2.55

1. Water

Water used all along this research work either in casting or in curing process was free from any detrimental contaminant and was as per IS 456-2000 requirements.

1. Fly-Ash

1. Design Mix of M30

- Type of Cement: 53 Grade
- Specific Gravity of Cement : 3.01
- Size of Coarse Aggregate : 20 mm
- Specific Gravity of Coarse Aggregate : 2.78
- Specific Gravity of Fine Aggregate : 2.77

- Slump Required : 120 mm
- Exposure : Moderate
- Min. Cement Content : 240 kg/m^3
- Max. Water Content : 0.60
- f_{ck} : 30 N/mm2
- Standard Deviation : 5 N/mm^2

1. Target Strength for Mix Proportion :

$F_{ck} = f_{ck} + 1.65 \times SD$

= 30 + 1.65 x 5

= 38.25 N/mm^2

2. Selection of water Content :

Max. Water Content for 20mm aggregate = 186 litre (From IS 10262:2019) Estimated Water Content for 120 mm slump = 186 + 8.4/120 x 186 = 199.02litre

3. Calculation of Cement Content :

Water Cement Ratio = 0.45

Cement Content = Water Content / Water-Cement Ratio = 199.02/0.45 = 442.26kg/m^3

4. Calculation of Coarse and Fine Aggregate and Fine Aggregate : Volume of Coarse aggregate = 0.62 x 0.9 = 0.56

Volume of Fine aggregate = 1–0.56 = 0.44

5. Mix Calculations:

The Mix calculations per unit volume of concert

b) Volume of Cement = (Mass of cement/Specific Gravity of Cement) x (1/1000)

= (442.26/3.15) x 1/1000

= 0.14m^3

c) Volume of Water :

(Water Content / Specific Gravity of Water) x (1/1000)

= (199.02/1) x 1(/1000)

= 0.199m^3

d) Volume of all in Aggregate :

a - (b + c)) = 1 - (0.14 + 0.199) = 0.66 m^3

e) Mass of Coarse Aggregate :

Volume of all in aggregate x Volume of coarse aggregate x Specific gravity of Coarse Aggregate x 1000

= 0.66 x 0.56 x 2.78 x 1000

=996.35 kg

f) Mass of Fine Aggregate =

Volume of all in aggregate x Volume of Fine Aggregate x Specific Gravity of Fine Aggregate x 1000

= 0.64 x 0.44 x 2.77 x 1000

= 780.032 kg

Mix Proportions :

Cement : Fine Aggregate : Coarse Aggregate 1 : 1.76 : 2.25

4. Results And Discussion

4.1 Fresh Properties of concrete

1. Workability:

Workability is defined as the ease with which the concrete is placed and compacted homogeneously without showing any bleeding or segregation. Here we checked the workability from slump and it was found to be 120 mm. The value of slump decreases with the increase in the amount of Sawdust.

4.2Hardened Properties of concrete

1. Compressive Strength: For 7 and 28 days

The compressive strength tests for 7 and 28 days result show that up to 20 % Fly Ash shows good compressive strength than control mix and then it gradually decreases with the increase in the

%ages replacement of fly ash. This is because of the superior adhesive properties of fly ash that provide a better strength to the concrete. Maximum load applied in Newton at which the cubes failed divided by the cross sectional areas of the cubes in mm^2 gives the compressive strength of that particular cubes in N/mm^2 or MPa. Concrete is good in compression.

1. Split Tensile Strength: For 7 and 28 Days

The split tensile strength tests show that up to 20 % of sawdust replacement provided 20% Fly Ash and 4% coir shows good split tensile strength than Control Mix and then gradually decreases with increases in percentage replacement of sawdust. Split tensile strength is measured as per IS 5816:1999. To find such strength, we follows formula fct = 2p/ πld where p is the maximum load applied to cylinders, π is a constant, l is the height and d is the diameter of the cylinder.

1. Flexural Strength: For 7 and 28 Days

The flexural strength tests of beams up to 15% replacement sawdust provided 20% Fly Ash, 4% coir show good flexural strength than Control Mix and gradually decreases with increase in the percentage sawdust replacement. This is because of the high fibre content which captured and minimized the splits present in the solids and hence improved the flexural strength of the beams. Flexural strength is measured following Indian Codes 516:1959. Fb = pl/bd^2 is the formula adopted to calculate bending strength, where p is the maximum load applied to which the beam failed, l is the length of a beam, b is the breadth and d is the depth of a beams.

1. Laboratory Investigation

1. Investigation for cement

Ordinary Portland cement (OPC) of grade 43 is adopted in this research work. Following are the laboratory equipment adopted for testing the properties of cement:

- Vicat apparatus: Consistency test, initial and final setting time of cement is carried out using this apparatus
- Weighing balance: Used for weighing cement sample

1. Investigation for fine aggregate and coarse aggregate

The fine aggregate and coarse aggregate adopted to use in this study were first tested and these are some of the following laboratory equipment used for testing them:

- Thermostatically controlled oven machine: Used for drying the sample
- Pycnometer: specific gravity of fine aggregate is tested by using this apparatus
- Weighing balance: to measure the sample used
- IS Sieve : sample is sieve to the desired size by these standard sieve size

4. Investigation for Fly-Ash

Fly-Ash of class-C were collected and sieves with a sieve size of 90microns

1. Testing Investigation

4.4.1Investigation test for Compressive Strength

Cubes specimen is undergo testing by Compression Testing Machine (CTM). The load capacity of this machine used is of 1000 KN. Specimen are placed and the procedure follows as per IS 516. Rate of testing is set 5.1 KN/sec. Compressive strength is calculated as Maximum load applied in Newton at which the cubes failed divided by the cross sectional areas of the cubes in mm^2 gives the compressive strength of that particular cubes in N/mm^2 or MPa .The setting of specimen is shown in Figure below

4.4.2Investigation test for Split-Tensile Strength

Split-tensile strength is determine using the formula fct=2p/πld, where p is the maximum load applied to cylinders, π is a constant, l is the height and d is the diameter of the cylinder. Split tensile strength is measured as per IS 5816:1999. The setting of specimen is shown in fig below:

4.4.3Investigation test for Flexural Strength

Flexural strength is calculated using formula $fb=Pl/bd^2$, where p is the maximum load applied to which the beam failed, l is the length of a beam, b is the breadth and d is the depth of a beams. Flexural strength is measured as per IS 516:1959. The setting of specimen is shown in figure

TEST	7days	14days	28days
Compressive strength(N/mm²) (For conventional concrete)	23.5	33.81	38.96
Tensile strength(N/mm²) (For conventional concrete)	2.29	2.38	2.42

Compressive strength for different proportion of fly ash after 7days curing

%of fly ash	Compressive strength(N/mm²)
0%	23.5
10%	26.20
20%	25.3

30%	20.91

Compressive strength for different proportion of fly ash after 14days curing

%of fly ash	Compressive strength(N/mm²)
0%	33.81
10%	38.14
20%	34.72
30%	27.49

Compressive strength for different proportion of fly ash after 28days curing

% of fly ash	Compressive strength(N/mm²)
0%	38.96
10%	43.24
20%	37.78
30%	31.46

5. Conclusions

The 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days.

- The 30% replacement of cement with fly ash ultimate compressive strength of concrete decrease.
- Use of fly ash reduces the amount of cement content.

Construction work with fly ash concrete becomes environmentally safe and also economical.

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